Report No. 360

MECHANICAL DEPARTMENT

ADMIRALTY ENGINEERING LABORATORY

WEST DRAYTON, MIDDLESEX

PERKINS SIX '354' MARINE ENGINE.

ADMIRALTY TYPE TEST PART I.

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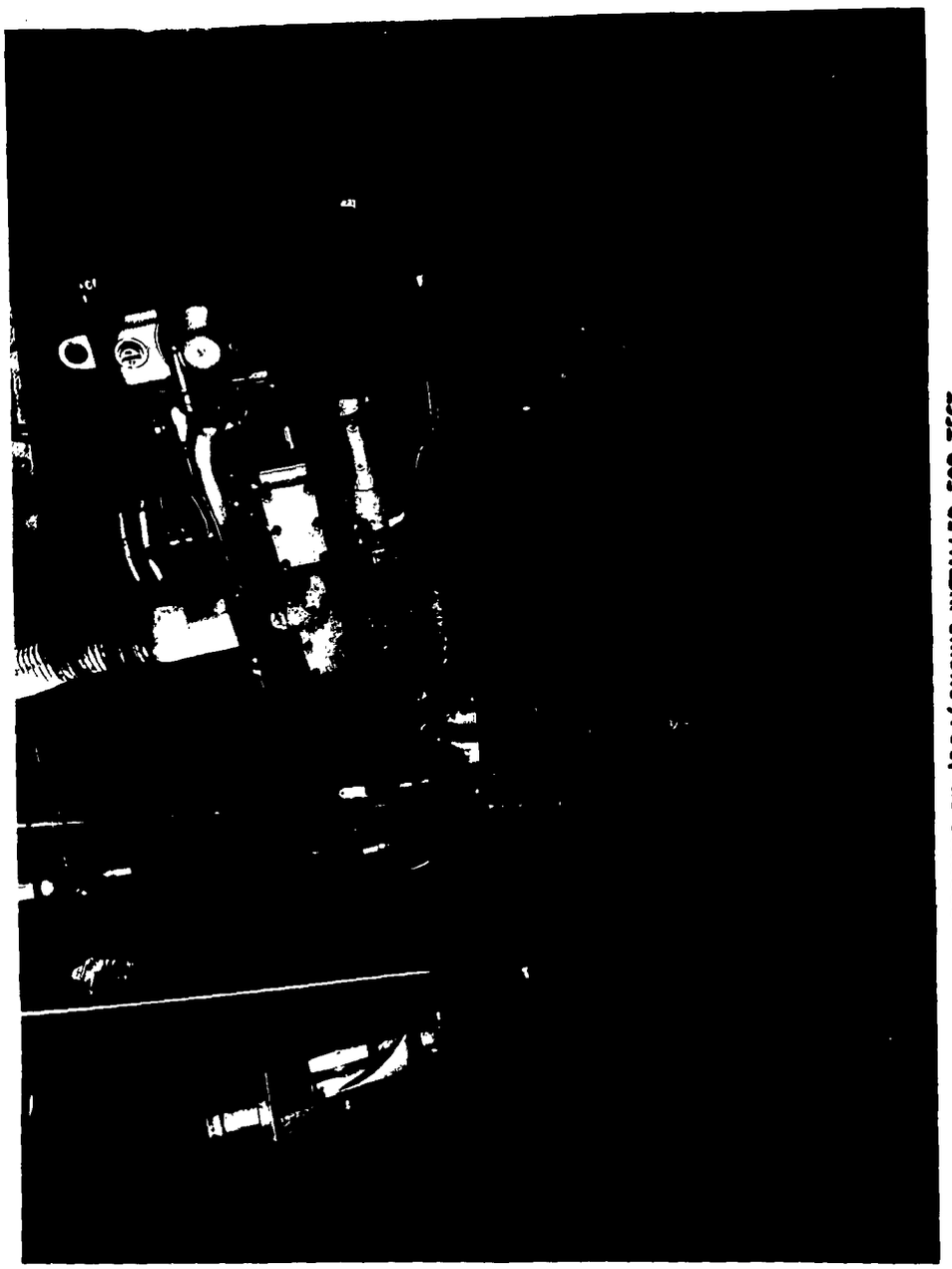

PERKINS SIX '354' ENGINE INSTALLED FOR TEST.

A.E.L. REPORT NO. 366.

SEPTEMBER, 1962.

ADMIRALTY ENGINEERING LABORATORY

WEST DRAYTON.

PERKINS SIX '354' MARINE ENGINE.

ADMIRALTY TYPE TEST PART I.

Approved

Deputy Superintendent.

Superintendent.

SUMMARY.

The Admiralty Type Test Part I of the Perkins Six '354' Marine Engine is reported.

The engine was given an Admiralty Test Rating of 95 b.h.p. at 2400 r.p.m.

The test was completed in May 1962.

A.E.L. REPORT NO. 366.

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SEPTEMBER, 1962.

ADMIRALTY ENGINEERING LABORATORY
WEST DRAYTON.

PERKINS SIX '354' MARINE ENGINE.
ADMIRALTY TYPE TEST PART I.

INTRODUCTION.

The Perkins Six '354' Marine Engine (No. 8002730) tested was supplied from current production in October 1961 and was tested as received without gearbox.

The gearbox (to be supplied by Messrs. Self-Change Gears Ltd.) will be fitted for Part III of the Type Test.

ENGINE DATA.

Vertical four-stroke, direct injection, compression ignition engine.

6 cylinders-in-line 3.875 inch bore x 5 inch stroke Maker's Rating (Marine) 105 s.h.p. at 2400 r.p.m. (intermittent).

Admiralty Test Rating: 95 b.h.p. at 2400 r.p.m.

PRINCIPAL RESULTS.

Test	Average fuel consumption lb./b.h.p./hr.	Exhaust shade	Average lubricating oil consumption	
			lb./hr.	% Fuel
72 hours at 95% A.T.R.	0.381	C/SS	0.032	0.08
12 hours at 100% A.T.R.	0.378	C/SS	-	-
2 hours at 110% A.T.R.	0.375	C/SS	-	-

RANGE OF TESTS.

	r.p.m.	b.h.p.	b.m.e.p. p.s.i.
Loop Test	1500	26.8 - 73.7	40 - 110
"	1800	32.1 - 88.4	40 - 110
"	2000	35.7 - 98.2	40 - 110
"	2200	39.1 - 108	40 - 110
"	2400	42.9 - 110.7	40 - 104.4
"	2500	44.6 - 109.8	40 - 98.4

For results, see Table 1 and Figs. 1 - 7.

ENDURANCE.

72	hours	at	95%	A.T.R.	2400	r.p.m.	90.3	b.h.p.	84.1	p.s.i.b.m.e.p.
12	"	"	100%	"	2400	"	95.0	"	88.5	"	"
2	"	"	110%	"	2400	"	104.5	"	97.3	"	"

For results see Tables 2 and 3.

TEST PROCEDURE.

The engine was installed with four L-type anti-vibration mountings on a test bed inclined at 15° to the horizontal and coupled through a cardan shaft to a Heenan and Froude DPX.3 dynamometer.

Distilled water was used in the coolant circuit. The raw water inlet temperature was variable between 62° and 85°F.

TEST DATA.

Fuel:	S.G. at 60°F:-	0.8390
	Cetane No:-	59
	Sulphur:-	0.91%
Lubricating Oil:	OMD.112.	
	(For analyses see Table 4).	

DEFECTS ARISING DURING TEST.

No defects developed during the test.

GENERAL REMARKS.

Construction. (See Fig.13).

The crankcase and cylinder block is a one piece high duty iron alloy casting. The sides of the block extend below the crankshaft centre line to form a stiffening skirt for the main bearing housing ribs. The cylinder block carries the centrifugally cast dry liners which are renewable.

The crankshaft, of chrome molybdenum steel is carried in seven main bearings, end float being controlled by steel-backed lead bronze faced thrust washers located in the centre bearing cap and housing. A viscous vibration damper is fitted to the crankshaft pulley at the free end of the engine.

The large end and main bearing shells are lined with aluminium-tin and the large end bearing caps are located to the rod by serrations.

The cylinder head is a one piece alloy iron casting with a conventional overhead valve gear arrangement. The combustion chamber is formed by the toroidal piston cavity.

The fuel injection pump is of the distributor type with built-in hydraulic governor, flange mounted, and driven by a worm integral with the auxiliary drive shaft. Single helical gears are employed for the timing gear train at the free end of the engine.

The engine is complete with all accessories and it should be noted that the engine lubricating oil cooler is sea-water cooled, the cooler being sited to draw inlet sea-water via the gear box oil cooler (when fitted) on the suction side of the sea-water pump.

Accessibility.

Accessibility for routine maintenance is good. Stripping for major overhaul is straightforward, no special tools are required but the use of an overhaul stand is recommended.

The engine can be completely stripped by one mechanic in approximately 8 hours. (It is necessary to remove the bell housing to remove the crankshaft). Re-building the engine takes approximately 15 hours.

Starting.

No difficulty was experienced in starting the engine at normal ambient temperatures. No cold start tests have yet been attempted. It was found that after emptying the lubricating oil from the sump it was necessary, with the engine set up at 15° to the horizontal, to prime the oil system to raise oil pressure on starting. This condition may possibly be corrected by an oil pump having a finer rotor clearance which will be fitted before commencing any further tests.

Slow Running.

The engine when warm will idle down to 300-350 r.p.m. but the minimum speed without its rocking on its mountings, is 700-750 r.p.m.

Vibration and Noise.

The engine appears to be noisy at speeds over 2200 r.p.m. but below this speed the noise level compares favourably with engines of similar power. Apart from very low speeds (300-700 r.p.m.) the engine did not appear to have any critical vibration period.

Combustion.

The combustion characteristics of the engine are good but the exhaust is not completely clean at any power. Noticeable shading is apparent at approximately 90 p.s.i. b.m.e.p. and above.

Lubricating Oil.

The consumption of lubricating oil during the 72 hour 95% A.T.R. endurance test was extremely low, but no ill effects were shown by the piston/liner working surfaces.

The combination of low oil consumption and oil temperatures around 190-200°F is thought to have caused the fairly rapid deterioration of the oil. The analysis check after 134 hours running showed the oil to have a Strong Acid Number (to pH4) of 1.52. (See Table 4).

The oil was changed at this time, the engine running only five more hours before completion of the test.

Condition After Test.

The general condition of the engine after test is considered satisfactory, no excessive wear being seen on any major component.

The appearance of the large end bearing shells particularly No.1 has been established by the bearing makers as being due to dirt, possibly introduced from the casting oil passages.

The exhaust valve stems show marked signs of dragging in the guides. The latter have been modified in later production by a counterbore at their lower ends, to eliminate this condition.

CONCLUSIONS.

1. The engine has been given an Admiralty Test Rating of 95 b.h.p. at 2400 r.p.m. and can be recommended for Admiralty service.

2. The power available for boat propulsion through a reduction gearbox will be determined before commencing a 1000 hour endurance test for that application.

E.J. Watts, Sen.Sci.Asst.

Submitted by W.H. Ray, P.S.O.

AEL/RO/PC.

SPECIFICATION AND COMPONENT REPORT.

Maker: Perkins Engines Ltd., Peterborough.

Type: Vertical four-stroke in-line compression ignition engine.

Type No.: Six '354'(M).

Purpose: Marine Propulsion.

Maker's Continuous Rating: 81 s.h.p. (Direct drive) at 2000 r.p.m.

Admiralty Test Rating: 95 b.h.p. (no gearbox) at 2400 r.p.m.

No. of Cylinders: Six.

Bore: 3.875"

Stroke: 5.0"

Total Swept Volume: 354 cu.ins. (5.8 litres).

Compression Ratio: 16:1

Piston Speed: 2,000 ft./min. at 2400 r.p.m.

Firing Order: 1, 5, 3, 6, 2, 4.

Lubricating Oil Capacity: 23 pints.

Rotation Viewed from Free End: Clockwise.

Timings:

Inlet valve opens	13° before T.D.C.
" " closes	43° after B.D.C.
Exhaust valve opens:	56° before B.D.C.
" " closes:	10° after T.D.C.
Injection (static) begins:	28° before T.D.C.

Tappet Clearance: 0.010" (Hot)

Overall Dimensions: (Without gearbox).

Length	44"
Width	29"
Height above crankshaft	23⅝"
Depth below crankshaft	10"

Weight: 1164 lb. (Without gearbox but including all ancillaries).

Wt./b.h.p. at 95 b.h.p. (Admiralty Test Rating) 12.3 lb.

Wt./cu.in./Swept Volume 3.29 lb.

b.h.p./Litre 16.3

PARTICULARS OF ENGINE	CONDITION AFTER TEST. 135 Hours at A.E.L.	9

CRANKSHAFT.

Material: Forged chrome-molybdenum steel EN.19C. Journals and crankpins, induction hardened.

No. of Bearings: Seven.

Balance Weights: None fitted.

Vibration Dampers: One 8" diameter viscous type.

Flywheel Location: Bolted to flange, drive end of crankshaft.

Drilling: For large end lubrication.

Main Bearing Journals: Satisfactory, light surface scratching only.

Crankpins: Satisfactory, light surface scratching only.

MAIN BEARINGS.

Type: Replaceable thin wall steel backed shells.

Lining: Aluminium-tin.

See Fig.8.
Severe scoring on some shells probably due to initial assembly dirt. Thrust washers satisfactory.

CRANKCASE AND CYLINDER BLOCK.

Type: Monobloc construction.

Material: High duty cast iron BS.1452 Grade 14.

No undue deposits. Generally clean condition.

CYLINDER LINERS.

Type: Dry. Renewable.

Material: Centricast alloy iron.

Bore Finish: Honed to 16-48 micro ins.

Well polished appearance over piston ring travel. Some very light scratching visible in some bores and light patches of lacquer on some walls. Ring of carbon deposit above top ring travel in all bores.

PARTICULARS OF ENGINE	CONDITION AFTER TEST.
CYLINDER HEADS.	
Material: Cast Iron BS.1452 Grade 17.	Light hard carbon deposit evenly distributed over each cylinder bore.
Number: One.	
Valve Seatings: Integral with head.	Exhaust valve seats appear blackened and some light pitting visible. Inlet valve seats: Generally satisfactory.
Valve Guides: Replaceable, cast iron, inserts.	
Position of Injectors: L.H. side of head external to rocker box.	
Gasket: Copper steel asbestos.	Satisfactory.
PISTONS.	See Fig.9.
Material: High silicon aluminium alloy S.132. (Wellworthy).	
Shape of Crown: Contains toroidal cavity.	Crowns: Light dusting of carbon in piston bowls and tops.
	Top Lands: Light carbon and lacquer deposit fairly evenly disposed on each piston with some very light carbon cutting.
	Ring Lands: Lacquer deposit generally on all lands with some carbon build-up.
	Skirts: Generally clean, some light lacquering fore and aft. on all pistons.
No. of Compression Rings: Three (One plain chrome. (Two taper faced.	All free and of good appearance. Taper faced rings bedded approx. $\frac{1}{3}$ across faces.
No. of Oil Scraper Rings: Two, slotted type, one above and one below the gudgeon pin.	All free and of good appearance.

PARTICULARS OF ENGINE	CONDITION AFTER TEST
GUDGEON PINS.	See Fig.9.
Material: Steel BS.En.352.	Satisfactory appearance. No visible wear.
Type: Fully floating.	
Location: By circlips.	
CONNECTING RODS.	
Material: Steel stamping lead bearing BS.970.En.16.	
Centre Distance: 8.625"	
Drilling: Nil.	
Type of Large End Bearing: Pre-finished replaceable steel backed shells.	See Fig.10. No.1 Large end bearing shells show peculiar blistering of metal surface and considerable scoring due to dirt. Remainder show surface scratching only.
Lining: Aluminium-tin.	
Material of Small End Bush: Steel backed, lead bronze lined.	Satisfactory appearance.
VALVES.	
Inlet.	See Figs. 11 and 12.
Material: 1% Chrome steel EN.18s.	
No./Cylinder: One.	
Seat Angle: 45°.	Seats: Partially blackened, some very light pitting visible. Some carbon build-up under heads.
Throat Dia.: 1.746"	
Lift: 0.423"	Stems: Oily and free in guides.
No. of Springs/Valve: Two.	
Operation: By mushroom headed tappets, push rods and overhead rocker levers.	Tappets, Push Rods and Rockers: Satisfactory.

PARTICULARS OF ENGINE	CONDITION AFTER TEST
VALVES.	
Exhaust.	
Material: 21-4NS steel.	
No./Cylinder: One.	
Seat Angle: 45°	Seatings: Partially blackened, some very light pitting visible on some seats.
Throat Dia.: 1.408"	Stems: Oily and free in guides. Some lacquering of stems towards the head and some indications of dragging in the guides, particularly Nos. 6, 10 and 11. (See Fig.12).
Lift: 0.423"	Nos. 7 and 8 tappets show lacquering on the stems.
No. of Springs/Valve: Two	Push Rods and Rockers: Satisfactory.
Operation: By mushroom headed tappets, push rods and overhead rocker levers.	
CAMSHAFT.	
Material: High duty C.I. BS.1452 Grade 17 chilled.	Journals: Satisfactory appearance.
No. of Bearings: Four.	Cams: " " No visible wear.
Type of Bearing: Direct in cylinder block.	Bearings: " " " " "
Type of Cam Follower: Flat based tappets.	All of satisfactory appearance.
TIMING GEARS.	
Material: Crankshaft: Free M/c Carbon manganese, case hardening steel. Camshaft and Aux. Drive: BS.1452 Grade 17 C.I. Twin Idlers: Steel EN.202. Fuel Pump: Bronze S-W-W centrifugally cast.	All of satisfactory appearance.
Type: Helical spur.	
Location: Free end of engine.	

PARTICULARS OF ENGINE		CONDITION AFTER TEST
FUEL INJECTION PUMP.		
Make:	C.A.V. Ltd.	Performance satisfactory. Not examined.
Type:	Distributor. D.P.A. 3266136 with automatic advance and retard.	
Plunger Dia.:	9 mm.	
Location:	Flange mounted. L.H. side of crankcase, worm driven by auxiliary drive shaft.	
GOVERNOR.		
Make:	C.A.V. Ltd.	Performance satisfactory. Not examined.
Type:	Hydraulic.	
Location:	Integral with injection pump.	
INJECTORS.		
Make:	C.A.V. Ltd.	Spray on test: Good.
Holder Type No.:	BKBL.6785100	Release Pressure: 2600 p.s.i.
Nozzle Type No.:	BDLL.15086225	Needle Valves: All free. Carbon on tips. Stems clean.
No. of Holes:	Four.	Nozzle: Pressure faces pitted around edges of centre bore.
Dia. of Holes:	0.27 mm.	
Spray Angle:	150°.	
Release Pressure:	170 ats. 2500 p.s.i.	

PARTICULARS OF ENGINE	CONDITION AFTER TEST
FUEL FEED PUMP.	
Make: A.C. Delco. 0598E1.	Performance satisfactory. Not examined.
Type: Diaphragm.	
Location: R.H. side of crankcase operated by eccentric on engine camshaft.	
FUEL FILTERS.	
Make: C.A.V. Ltd. Drg.No. W.7005/2100.	Satisfactory.
Type: Paper element.	
No. Fitted: One.	
LUBRICATING SYSTEM.	
Type: Wet sump.	
Capacity: 23 pints (total).	
Type of Filters: Full flow paper element AC70 7111/296.	
No. of Filters: One.	No undue sludge or deposits found.
Normal Oil Pressure: 25-50 p.s.i.	
Type of Pressure Pump: Eccentric lobe type.	Satisfactory appearance. Some lacquering on rotor lobes visible.
Type of Oil Cooler: Sea-water cooled multi-tube Bowman No.781/74.	

PARTICUIARS OF ENGINE	CONDITION AFTER TEST
COOLING SYSTEM.	
Type: Closed circuit, cooled by heat exchanger.	
Capacity: 36 pints.	
Type of F.W. Pump: Centrifugal.	Satisfactory.
Location: Front end of cylinder block driven by pulley and V-belt from crankshaft.	
Type of S.W. Pump: 'Jabsco' rubber impeller, positive displacement.	Satisfactory.
Location: L.H. side of crankcase driven by auxiliary drive shaft.	
Type of Heat Exchanger: Multi-tube, with header tank.	Not examined.
Temperature Control: By bellows type thermostat. Control temperature 176°F.	Satisfactory.
ELECTRICAL SYSTEM.	
Make of Starter: C.A.V. (CA 45 C24-3M)	Performance satisfactory. Not examined.
Type of Starter: Solenoid operated. Bendix.	
Location: R.H. side of block at rear.	
Voltage: 24.	
DYNAMO.	
Make: C.A.V. (G5A24/33).	Used only as dummy for tensioning V-belt.
Type: Non-ventilated. Radio suppressed.	
Location: L.H. side of block.	
Voltage: 24.	

TABLE 1.

LOOP TESTS.

r.p.m.			1500	1800	2000	2200	2400	2500
b.m.e.p. p.s.i.		Max.	110	110	110	110	104.4	98.4
		Min.	40	40	40	40	40	40
Corresponding Exhaust Temperature °F.		Max.	760	815	865	890	920	880
		Min.	360	450	435	480	505	530
Coolant Temp. °F.	In	Max.	169	169	169	170	169	166
		Min.	165	157	147	164	158	160
	Out	Max.	182	183	183	185	182	180
		Min.	175	167	158	176	170	171
Raw Water Temp. °F.	In	Max.	82	83	84	85	84	83
		Min.	80	77	62	76	80	79
	Out	Max.	111	112	115	111	112	110
		Min.	95	96	78	92	96	90
Lubricating Oil Temperature °F.	In	Max.	145	153	161	164	172	174
		Min.	138	139	144	157	164	161
	Out	Max.	160	170	181	186	195	197
		Min.	150	151	161	176	185	189
Atmospheric Temp. °F.		Max.	92	89	98	98	105	96
		Min.	74	76	70	78	78	81

TABLE 2.

72 Hours Endurance Test 95% A.T.R. 90.3 b.h.p. 84.1 p.s.i. b.m.e.p. 2400 r.p.m.

			1st 24 hours	2nd 24 hours	3rd 24 hours	Total 72 hours
Fuel Consumption lb./b.h.p./hr.		Mean	.377	.383	.383	.381
		Max.	.383	.383	.383	.383
		Min.	.376	.383	.383	.376
Exhaust Temp. °F.		Mean	738	751	747	745
		Max.	750	760	755	760
		Min.	720	745	740	720
Exhaust Shade			C/SS	C/SS	C/SS	C/SS
Mean Exhaust Back Pressure "H_2O			1.6	1.5	1.7	1.6
Coolant Temp. °F.	In	Mean	167	166	165	166
		Max.	170	169	169	170
		Min.	165	162	160	160
	Out	Mean	182	181	181	181
		Max.	184	185	186	186
		Min.	176	177	175	175
Mean Raw Water Temp. °F.	In		81	79	81	80
	Out		105	103	105	104
Lubricating Oil Temp. °F.	In	Mean	171	169	169	170
		Max.	175	171	172	175
		Min.	168	162	164	162
	Out	Mean	196	193	193	194
		Max.	200	195	195	200
		Min.	192	188	189	188
Engine Lubricating Oil Press. p.s.i.			43	43	43	43
Mean Atmospheric Temp. °F.			84	85	85	85

TABLE 3.

12 Hours Test 100% A.T.R. 95.0 b.h.p. 88.5 p.s.i. b.m.e.p. 2400 r.p.m.

			1st 4 hours	2nd 4 hours	3rd 4 hours	Total 12 hours
Fuel Consumption lb./b.h.p./hr.		Mean	.378	.378	.378	.378
		Max.	.378	.378	.378	.378
		Min.	.378	.378	.378	.378
Exhaust Temp. °F.		Mean	775	780	761	772
		Max.	780	780	765	780
		Min.	765	780	760	760
Exhaust Shade			C/SS	C/SS	C/SS	C/SS
Mean Exhaust Back Pressure "H_2O			1.9	2.1	2.0	2.0
Coolant Temp. °F.	In	Mean	167	169	166	167
		Max.	168	170	168	170
		Min.	165	168	162	162
	Out	Mean	184	187	183	185
		Max.	186	187	186	187
		Min.	183	186	179	179
Mean Raw Water Temp. °F.	In		82	81	82	82
	Out		106	106	107	106
Lubricating Oil Temp. °F.	In	Mean	170	170	171	170
		Max.	170	170	172	172
		Min.	169	170	170	169
	Out	Mean	193	194	195	194
		Max.	194	194	195	195
		Min.	191	194	194	191
Engine Lubricating Oil Pressure p.s.i.			43	43	43	43
Mean Atmospheric Temp. °F.			81	84	93	86

TABLE 3. (Continued)

2 Hours Overload Test 110% A.T.R. 104.5 b.h.p. 97.3 p.s.i. b.m.e.p. 2400 r.p.m.

Fuel Cons. lb/bhp/hr.	Exhaust			Coolant Temp. °F		Raw Water Temp. °F		Lub. Oil Temp. °F		Atm. Temp. °F
	Temp. °F.	Shade	Back Press. "H_2O	In	Out	In	Out	In	Out	
.375	833	C/SS	2.7	169	187	83	110	173	196	95

TABLE 4.

OMD.112 Lubricating Oil Analysis.

Hours Run by Sample	Unused	134
A.O.L. Ref. No.	2783/62	3015/62
Flash Point °F	440	395
Viscosity Kinematic at 100°F c.s.	132	126
Pentane Insolubles % w.	Less than 0.01	0.43
Benzene Insolubles % w.	Less than 0.01	0.29
Acidity (Electrometric titration)		
Initial pH	8.2	2.1
Total Acid Number pH11 mg.KOH/g.	1.85	2.2
Strong " " pH4 "	Nil	1.52
Total Base " pH4 "	1.37	Nil
Carbon Residue (Ramsbottom) % w.	0.86	1.15
Sulphated Residue %	0.83	0.73

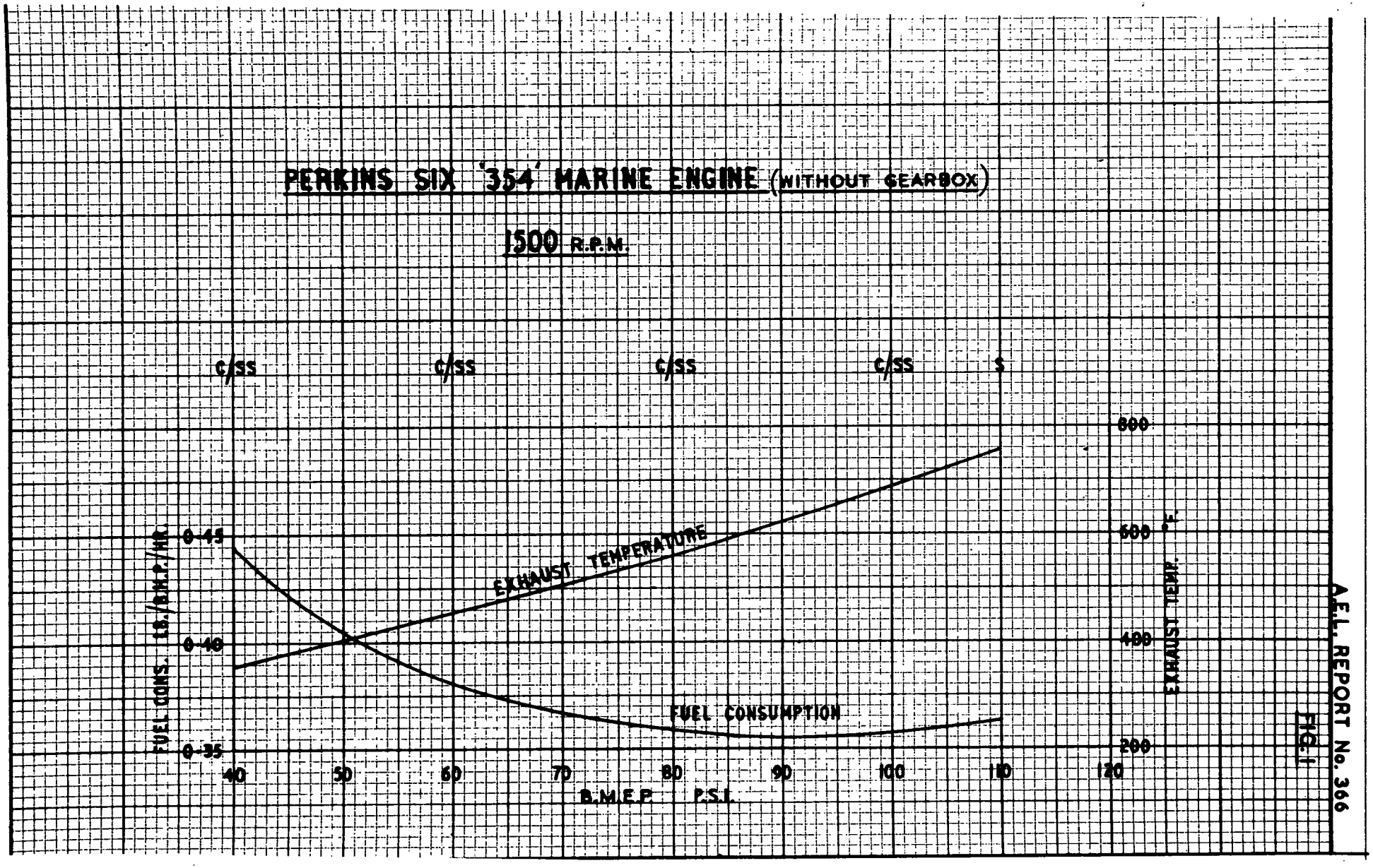

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FIG. 1

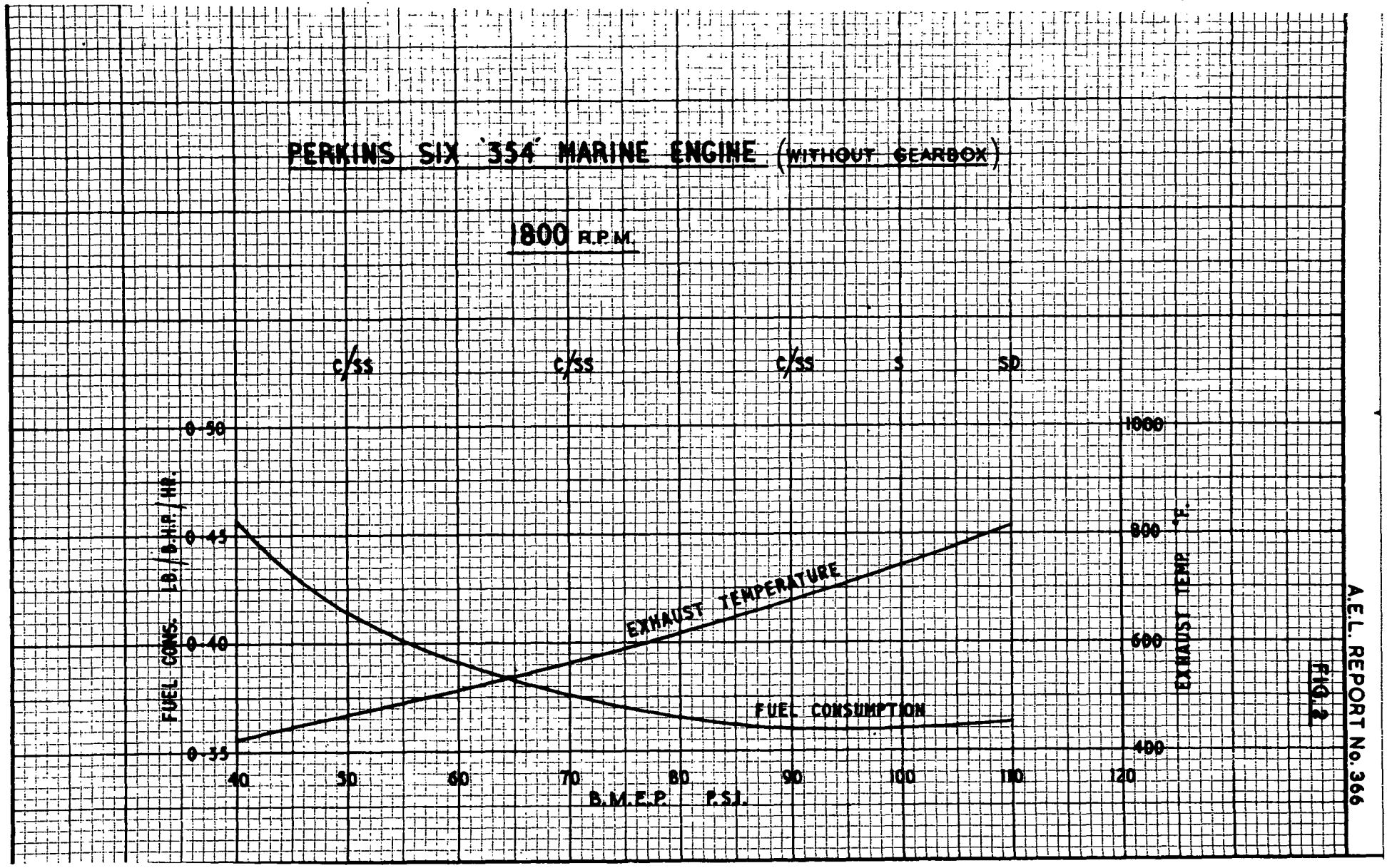

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FIG. 2

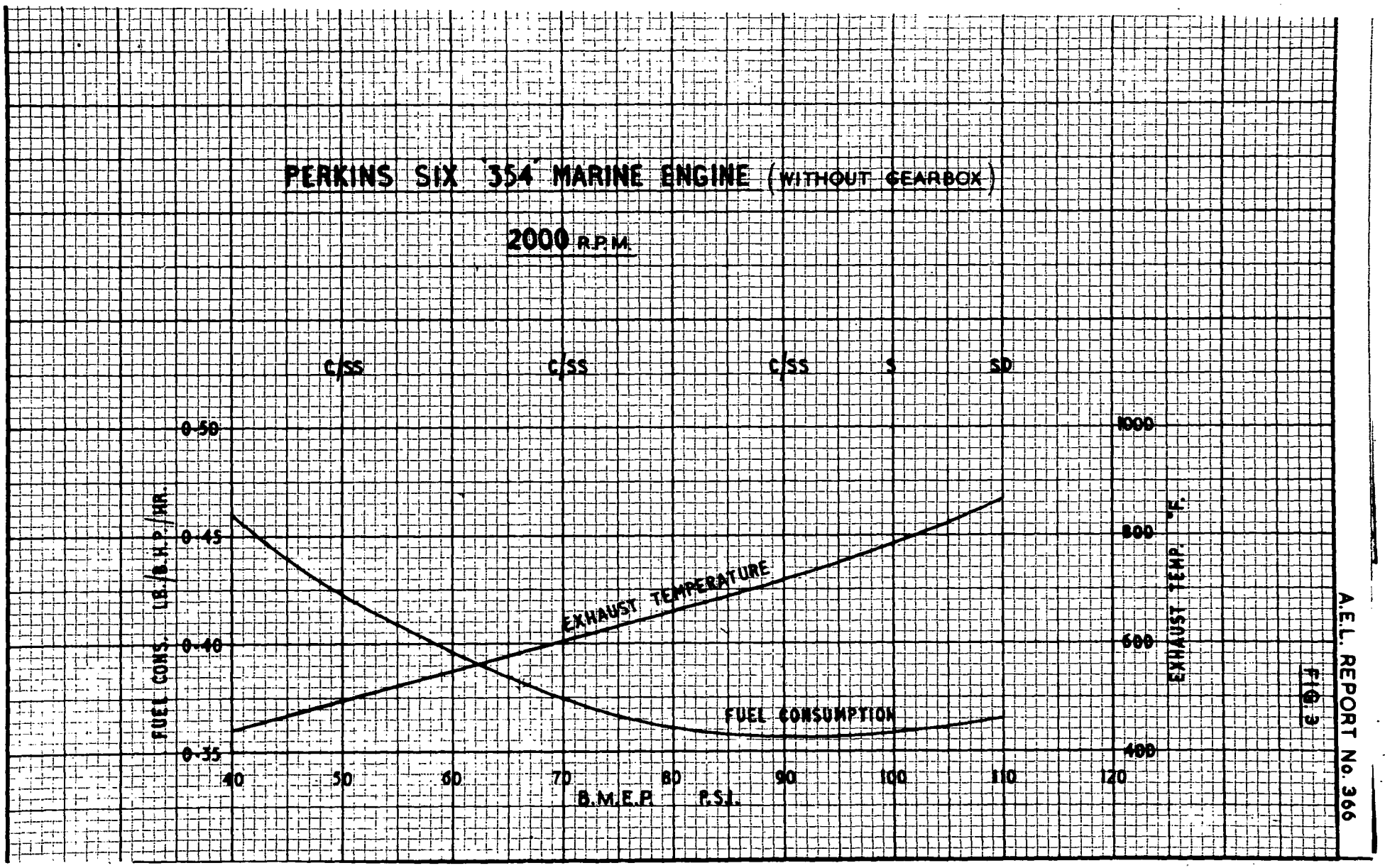

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FIG 3

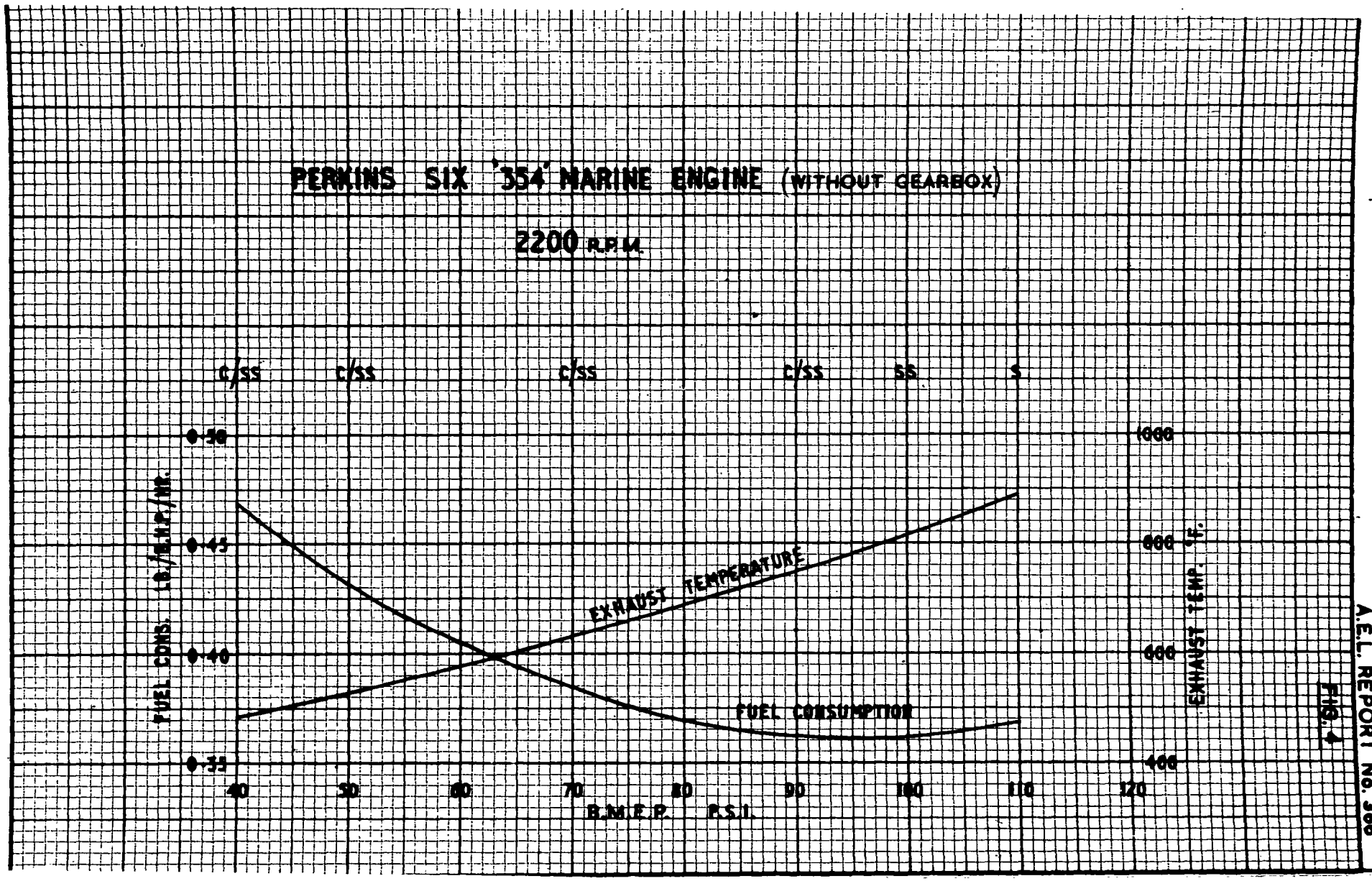

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FIG. 4

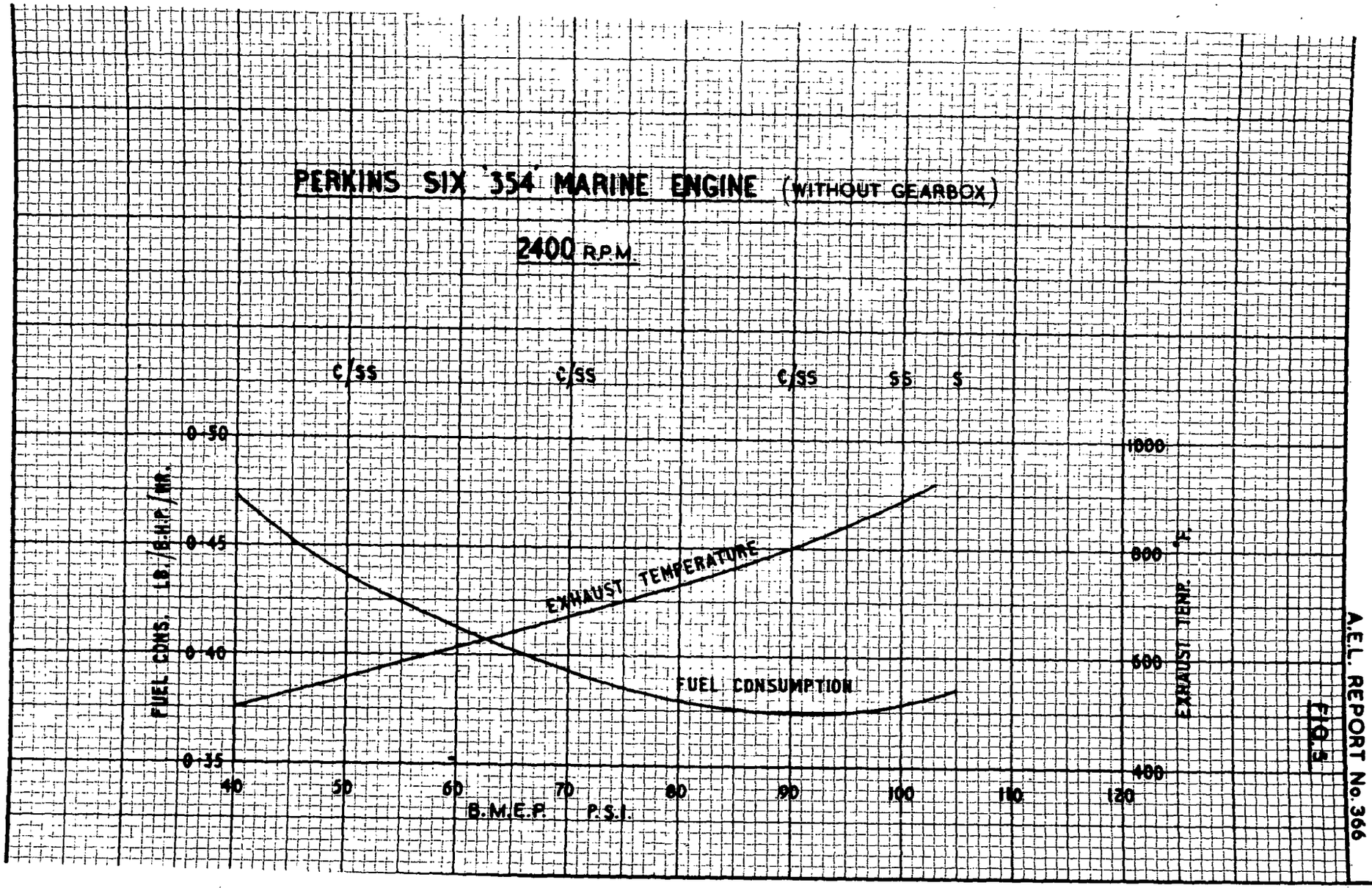

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FIG. 3

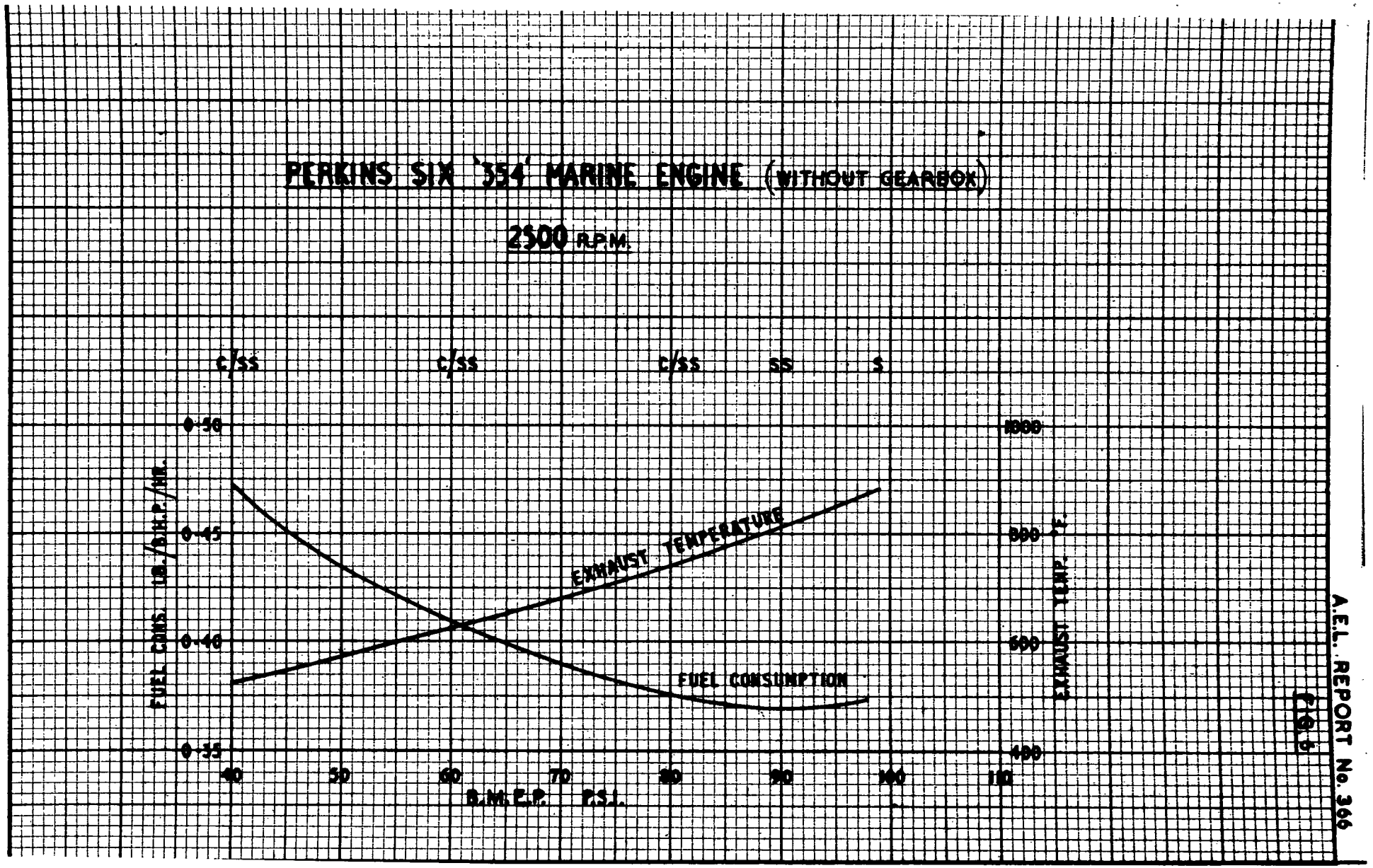

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FIG. 6

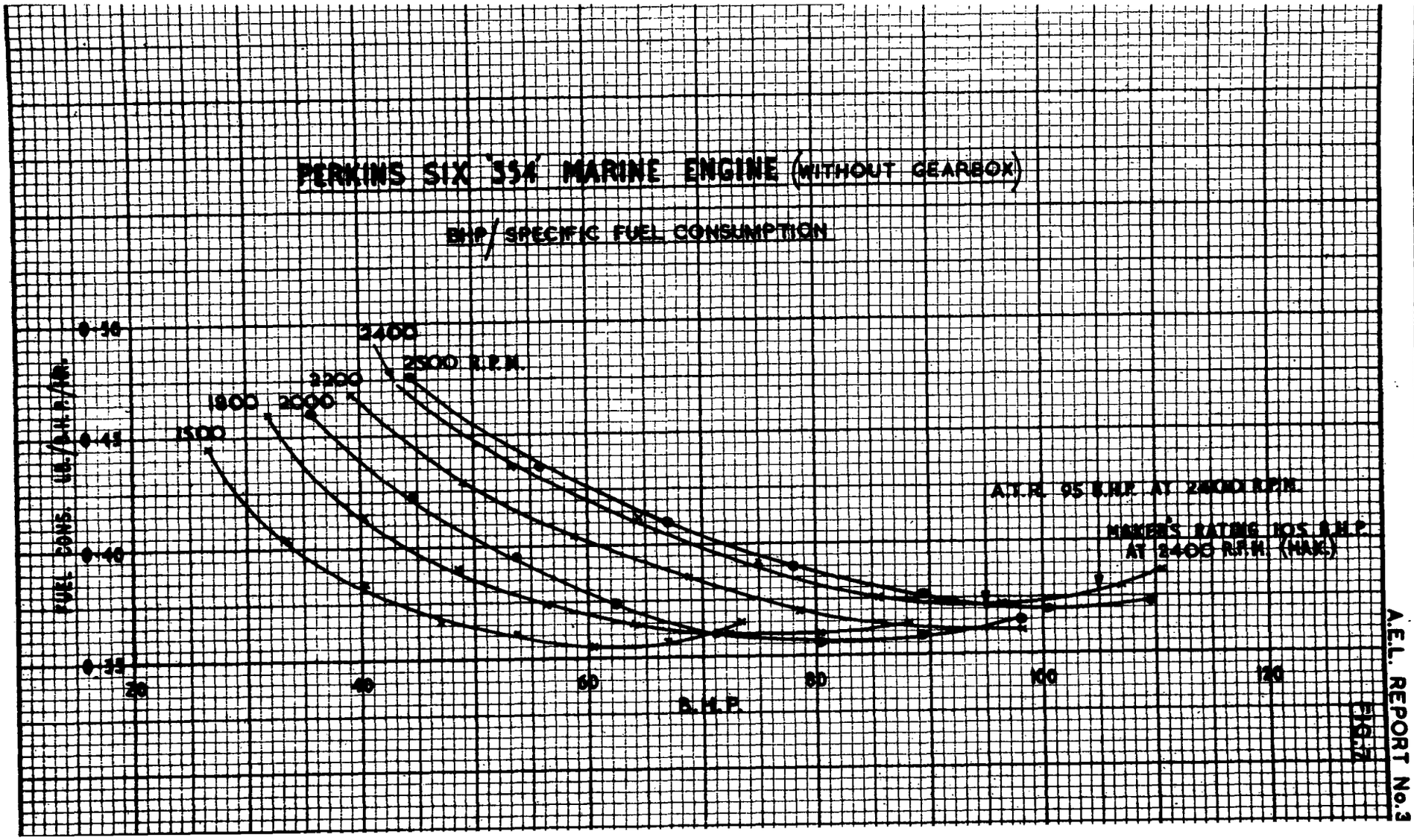

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FIG.4

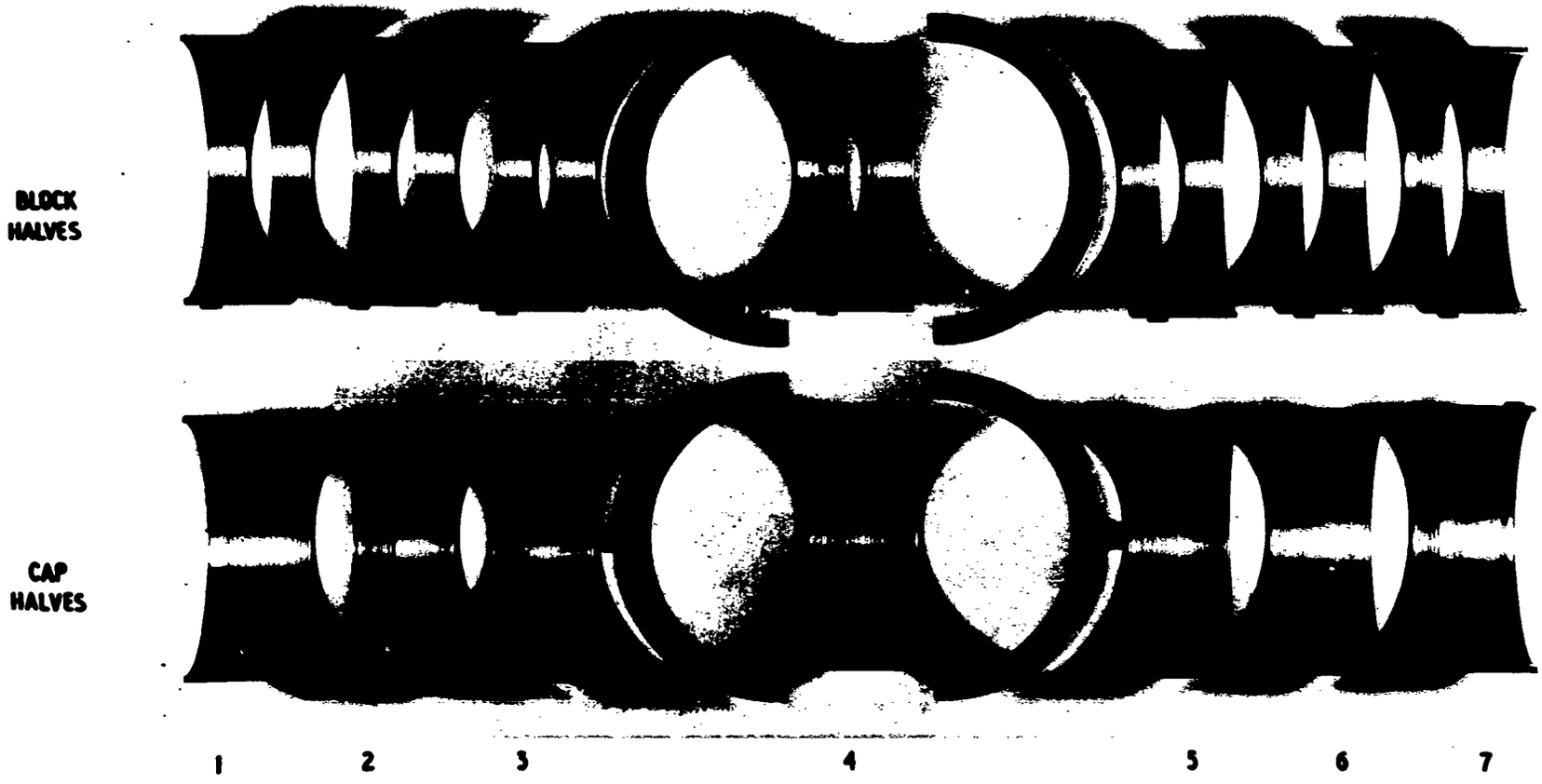

FIG. 8. MAIN BEARING SHELLS AND THRUST WASHERS.

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FIG. 8.

THRUST SIDE

1 2 3 4 5 6

ANTI-THRUST SIDE

FIG.9. PISTONS AND GUDGEON PINS.

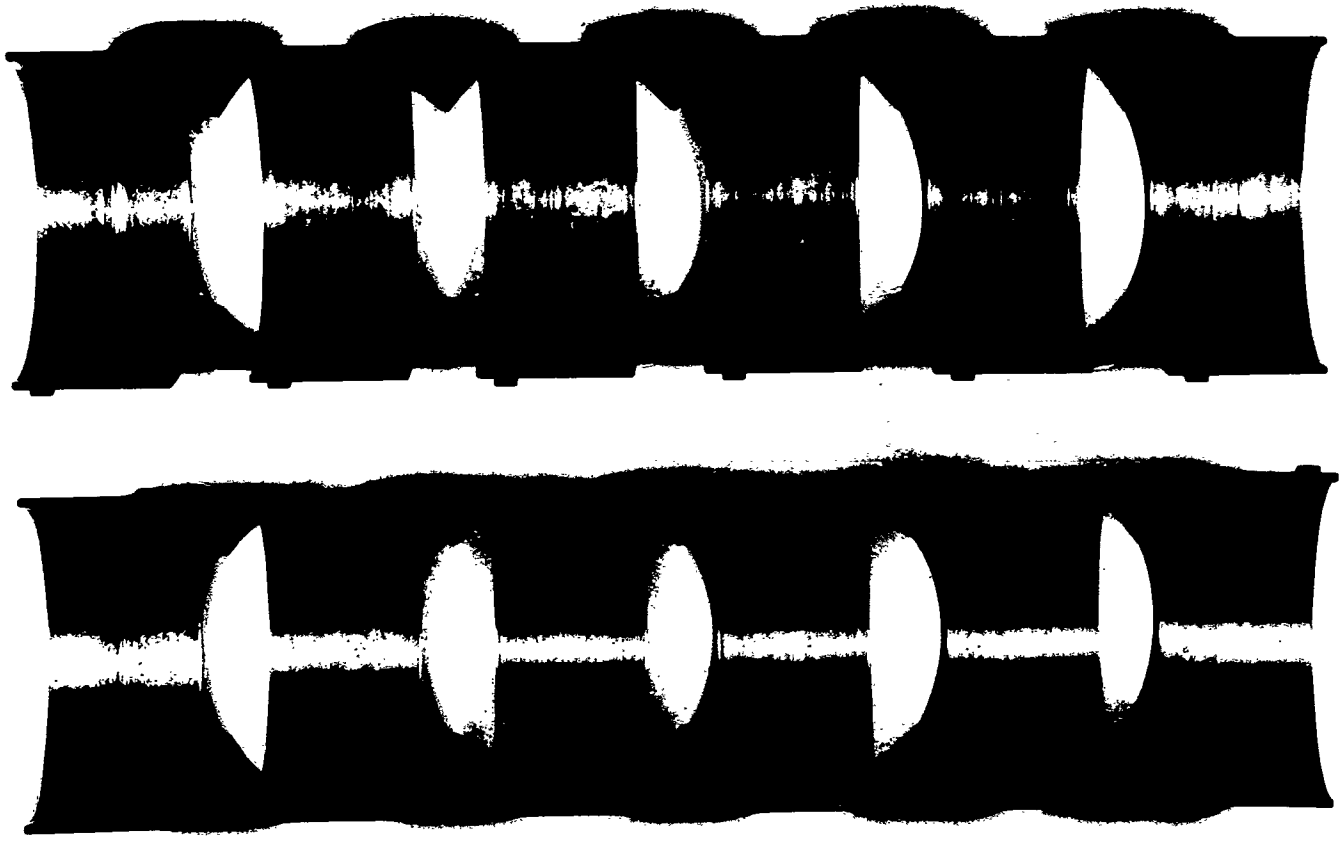

FIG.10. LARGE END BEARING SHELLS.

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FIG. 10.

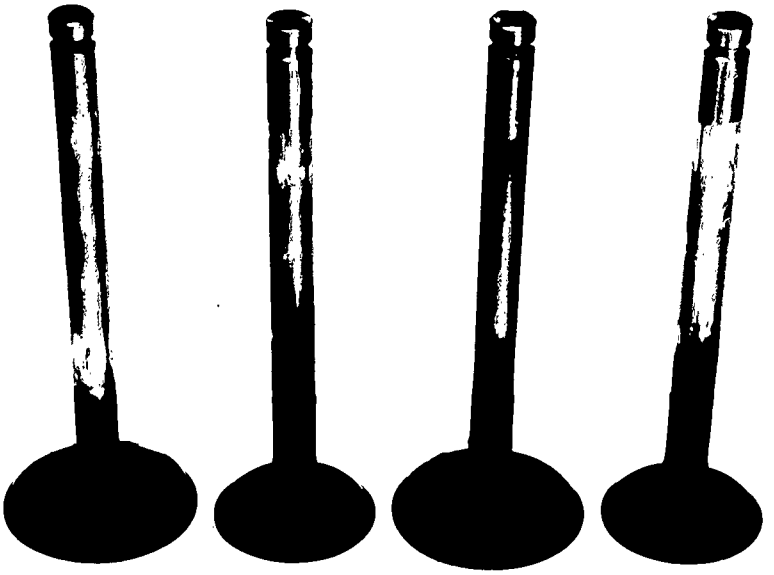

FIG.11. REPRESENTATIVE INLET AND EXHAUST VALVES.

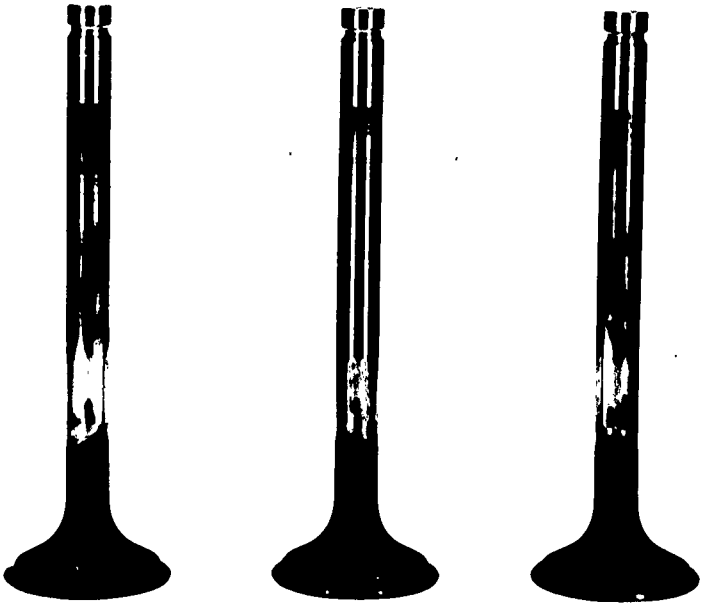

FIG.12. NOS. 6,10&11 (EXHAUST) VALVES SHOWING GUIDE DRAGGING MARKS ON STEMS.

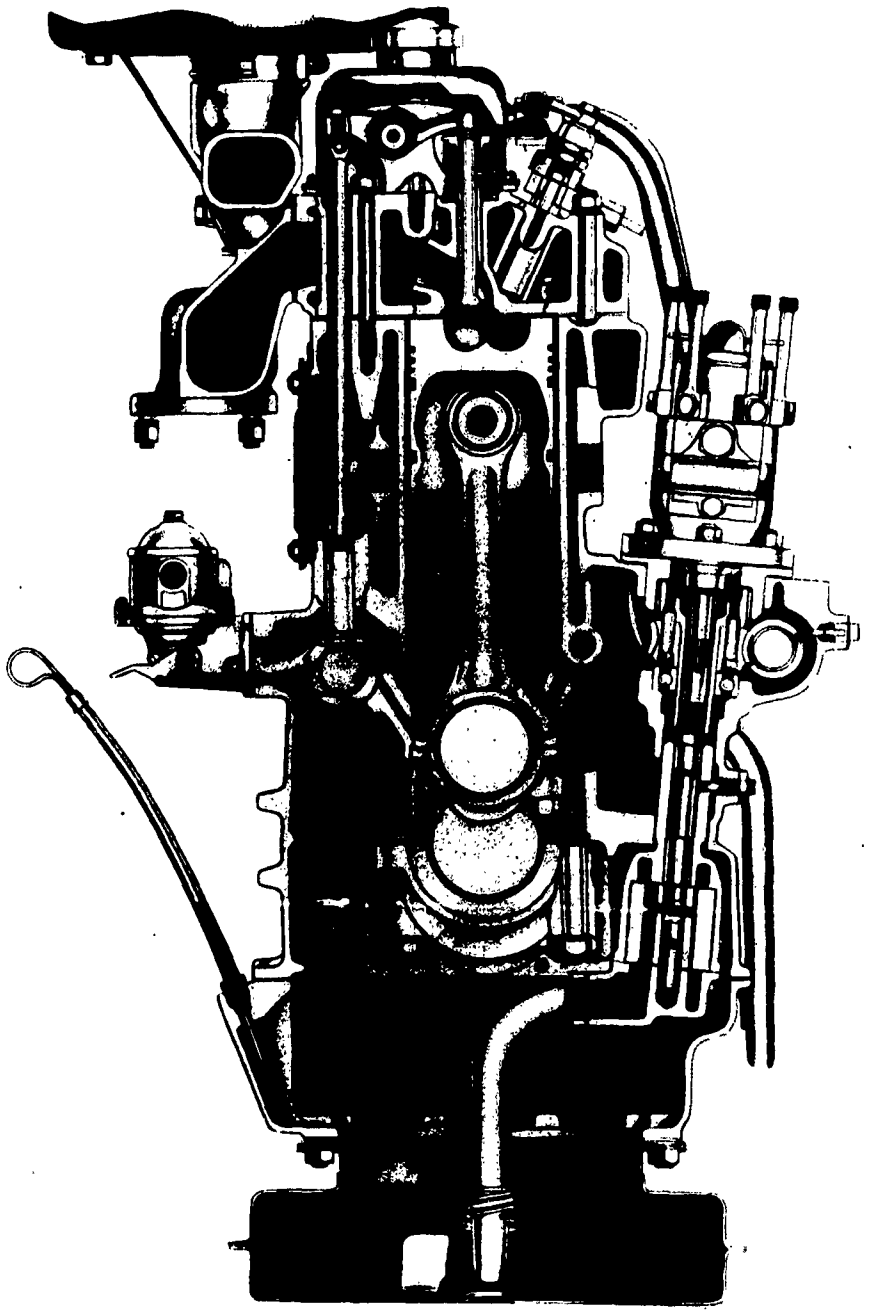

FIG.13. CROSS SECTIONAL VIEW PERKINS SIX '354' ENGINE.

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8725 John J. Kingman Road, Suit 0944
Fort Belvoir, VA 22060-6218
U.S.A.

AD#: AD297088

Date of Search: 13 August 2008

Record Summary: ADM 227/1910
Title: Perkin 6 354 marine engine: type test
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
Former reference (Department) Report No. 366
Held by The National Archives, Kew

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